

**REMARKS**

This is a full and timely response to the non-final Office Action mailed by the U.S. Patent and Trademark Office on January 31, 2006. Claims 1-23 remain pending in the present application. Claims 6-9 and 22-23 are objected to as being dependent on a rejected base claim, but would otherwise be allowable if rewritten in independent form.

Applicants wish to thank the Examiner for the indicated allowability of claims 6-9 and 22-23. However, Applicants have not yet amended independent claims 1, 12, 15 or 18 pending consideration of the following remarks. In view of the following remarks, reconsideration and allowance of the application and all pending claims are respectfully requested.

Each rejection presented in the Office Action is discussed in the remarks that follow.

**Rejections Under 35 U.S.C. § 102**

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Claims 1-5, 10 and 12-21 stand rejected under 35 U.S.C. § 102(b) as allegedly being anticipated by U.S. Patent No. 5,689,123 to Major *et al.* (hereafter *Major*). A proper rejection of a claim under 35 U.S.C. § 102 requires that a single prior art reference disclose each element of the claim. *See, e.g., W.L. Gore & Assoc., Inc. v. Garlock, Inc.*, 721 F.2d 1540, 220 USPQ 303, 313 (Fed. Cir. 1983). Anticipation requires that each and every element of the claimed invention be disclosed in a single prior art reference. *See, e.g., In re Paulsen*, 30 F.3d 1475, 31 USPQ2d 1671 (Fed. Cir. 1994); *In re Spada*, 911 F.2d 705, 15 USPQ2d 1655 (Fed. Cir. 1990). Alternatively, anticipation requires that each and every element of the claimed invention be embodied in a single prior art device or practice. *See, e.g., Minnesota Min. & Mfg. Co. v. Johnson & Johnson Orthopaedics, Inc.*, 976 F.2d 1559, 24 USPQ2d 1321 (Fed. Cir. 1992). The test is the same for a process. Anticipation requires identity of the claimed process and a process of the prior art. The claimed process, including each step thereof, must have been described or embodied, either expressly or inherently, in a single reference. *See, e.g., Glaverbel S.A. v. Northlake Mkt'g & Supp., Inc.*, 45 F.3d 1550, 33 USPQ2d 1496 (Fed. Cir. 1995). Those elements must either be inherent or disclosed expressly. *See, e.g., Constant v. Advanced Micro-Devices, Inc.*, 848 F.2d 1560, 7 USPQ2d 1057 (Fed. Cir. 1988); *Verdegaal Bros., Inc. v. Union Oil Co.*, 814 F.2d 628, 2 USPQ2d 1051 (Fed. Cir. 1987). Those elements must also be arranged as in the claim. *See, e.g., Richardson v. Suzuki Motor Co.*, 868 F.2d 1226, 9 USPQ2d 1913 (Fed. Cir. 1989); *Carella v. Starlight Archery & Pro Line Co.*, 804 F.2d 135, 231 USPQ 644 (Fed. Cir. 1986).

For anticipation, there must be no difference between the claimed invention and the reference disclosure, as viewed by a person of ordinary skill in the field of the invention. *See, e.g., Scripps Clinic & Res. Found. v. Genentech, Inc.*, 927 F.2d 1565, 18 USPQ2d 1001 (Fed. Cir. 1991).

Accordingly, the single prior art reference must properly disclose, teach or suggest each element of the claimed invention.

It is stated in the Office Action that:

[w]ith respect to claims 1 and 18, Major discloses a light-emitting device, comprising an active region configured to generate light in response to inject charge; and a tunnel junction located to inject charge into the active region and including an n-type tunnel junction layer of a first semiconductor material, a p-type tunnel junction layer of a second semiconductor material and a tunnel junction between the tunnel junction layers, the first semiconductor material including gallium (Ga), nitrogen (N), arsenic (As) and a Group VI dopant (col. 5, lines 66-67 and col. 6, lines 1-4).

Major discloses the formation of monocrystalline III-V compound semiconductor

materials having at least nitrogen and arsenic at group V lattice sites of the crystal material. *See Major*, col. 3, lines 51-54. Major continues stating "[t]he exact composition of a particular material to be produced, that is, the relative concentration of each of the group III and group V elements in the III-V compound, is generally selected so as to substantially lattice match with the selected substrate's growing surface." *See Major*, col. 3, lines 59-63. Importantly, nowhere does *Major* disclose, teach or suggest at least a tunnel junction structure or a method of making a tunnel junction structure. Applicants respectfully submit that a tunnel junction is a specific structure that exhibits specific properties.

Specifically, Applicants describe a tunnel junction structure and the operation thereof in the specification as follows:

Tunnel junctions having a low voltage drop are formed of materials that establish a large built-in electrostatic field across the tunnel junction. A large electrostatic field requires a large potential difference across a short distance, and is typically generated by using very high doping concentrations in the tunnel junction layers that minimize the width of the depletion region at the tunnel junction.

*See specification*, paragraph 0010.

A reverse bias applied across tunnel junction 110 adds to the height of the built-in potential barrier and increases the width of depletion region 204 to  $W'$ . The reverse bias separates the Fermi levels  $E_{Fn}$  and  $E_{Fp}$  on opposite sides of the tunnel junction. In the example shown, the Fermi level  $E_{Fp}$  of the material of p-type tunnel junction layer 106 has increased relative to its

equilibrium level, whereas the Fermi level  $E_{Fn}$  of the material of n-type tunnel junction layer 104 remains substantially unchanged. In a conventional p-n junction, only a small leakage current flows across the junction under reverse bias. However, in tunnel junction 110, the reverse bias causes current to flow and occurs due to electrons tunneling through the potential barrier.

*See specification, paragraph 0014.*

The reverse bias elevates the valence band energy  $E_{vp}$  of the material of p-type tunnel junction layer 106 above the conduction band energy  $E_{cn}$  of the material of n-type tunnel junction layer 104. This allows electrons in the valence band of the material of the p-type tunnel junction layer to tunnel through the potential barrier to unoccupied sites in the conduction band of the material of n-type tunnel junction layer 104, as shown schematically in Figure 2B. The greater the reverse bias applied across tunnel junction 110, the higher the probability that an electron,  $e^-$ , will tunnel across tunnel junction 110, and the higher the conduction through the tunnel junction.

*See specification, paragraph 0015.*

The voltage drop of the tunnel junction is lowered by forming the tunnel junction structure of a p-type tunnel junction layer and an n-type tunnel junction layer of semiconductor materials selected to have a reduced difference between the valence band energy of the material of the p-type tunnel junction layer and the conduction band energy of the material of the n-type tunnel junction layer. Reducing the energy difference between the valence band energy of the material of the p-type tunnel junction layer and the conduction band energy of the material of the n-type tunnel junction layer increases the tunneling probability at a given reverse bias, and, hence, reduces the voltage drop across the tunnel junction for a given current through the tunnel junction.

The difference between the valence band energy of the material of the p-type tunnel junction layer and the conduction band energy of the material of the n-type tunnel junction layer is reduced by adding nitrogen to the gallium arsenide of the n-type tunnel junction layer. The invention eliminates mutual passivation between the nitrogen and the n-type dopant used to dope the material of the n-type tunnel junction layer by doping the material of the n-type tunnel junction layer with a Group VI dopant, such as sulfur (S), selenium (Se), or tellurium (Te). The high active dopant concentration achievable using a group VI dopant further increases the tunneling probability, and reduces the voltage drop across the tunnel junction. In embodiments in which indium (In), antimony (Sb), or bismuth (Bi) is present in the p-type tunnel junction layer, the addition of N to the n-type tunnel junction layer allows the amount of In, Sb, and/or Bi to be increased. This has the effect of increasing the valence band edge in the p-type tunnel junction layer.

*See specification, paragraph 0025.*

Accordingly, Applicants respectfully submit that a tunnel junction is a specific structure that exhibits specific properties. Applicants also respectfully submit that a tunnel junction is neither disclosed, taught nor suggested by *Major*.

With particular regard to the claims, Applicants respectfully submit that *Major* fails to disclose, teach or suggest at least "a tunnel junction structure located to inject charge into the

active region and including an n-type tunnel junction layer of a first semiconductor material, a p-type tunnel junction layer of a second semiconductor material and a tunnel junction between the tunnel junction layers, the first semiconductor material including gallium (Ga), nitrogen (N), arsenic (As) and a Group VI dopant,” as recited in claim 1.

Further, Applicants respectfully submit that *Major* fails to disclose, teach or suggest at least “forming over the substrate an n-type tunnel junction layer of a first semiconductor material, the first semiconductor material including gallium (Ga), nitrogen (N), arsenic (As) and a Group VI dopant” and “forming over the substrate a p-type tunnel junction layer of a second semiconductor material juxtaposed with the n-type tunnel junction layer to form the tunnel junction,” as recited in claim 12.

Further, Applicants respectfully submit that *Major* fails to disclose, teach or suggest at least “forming a tunnel junction structure located to inject charge into the active region, including: forming an n-type tunnel junction layer of a first semiconductor material including gallium (Ga), nitrogen (N), arsenic (As) and a Group VI dopant” and “forming a p-type tunnel junction layer of a second semiconductor material juxtaposed with the n-type tunnel junction layer to create a tunnel junction,” as recited in claim 15.

Finally, Applicants respectfully submit that *Major* fails to disclose, teach or suggest at least “an n-type tunnel junction layer of a first semiconductor material including gallium (Ga), nitrogen (N), arsenic (As) and a Group VI dopant,” “a p-type tunnel junction layer of a second semiconductor material” and “a tunnel junction between the tunnel junction layers,” as recited in claim 18.

### Claims 2-3

Applicants respectfully submit that claims 2 and 3 recite features that are neither disclosed, taught or suggested by *Major*. Specifically, because *Major* does not describe or mention a tunnel junction, Applicants respectfully submit that *Major* fails to disclose, teach or suggest a light emitting device “in which the n-type tunnel junction layer is located between the p-type tunnel junction layer and the active region,” as recited in claim 2. Similarly, because *Major* does not describe or mention a tunnel junction, Applicants respectfully submit that *Major* fails to disclose, teach or suggest a light emitting device “in which the p-type tunnel junction layer is disposed between the n-type tunnel junction layer and the active region,” as recited in claim 3.

Accordingly, Applicants respectfully submit that independent claims 1, 12, 15 and 18

are allowable over *Major*, and furthermore, that dependent claims 2-5 and 10, which depend either directly or indirectly from allowable independent claim 1, dependent claims 13 and 14, which depend directly from allowable independent claim 12, dependent claims 16 and 17, which depend directly from allowable independent claim 15, and dependent claims 19-21, which depend directly from allowable independent claim 18, are allowable for at least the reason that they depend from allowable independent claims. *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1998).

### Rejections Under 35 U.S.C. § 103

#### Claims 2-3

Claims 2-3 stand rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over *Major* in view of U.S. Patent No. 6,724,013 to Kneissl (hereafter *Kneissl*). For a claim to be properly rejected under 35 U.S.C. § 103, "[t]he PTO has the burden under section 103 to establish a *prima facie* case of obviousness. It can satisfy this burden only by showing some objective teaching in the prior art or that knowledge generally available to one of ordinary skill in the art would lead that individual to combine the relevant teachings of the references." *In re Fine*, 837 F.2d 1071, 5 U.S.P.Q.2d 1596, 1598 (Fed. Cir. 1988) (Citations omitted). Further, "[t]he mere fact that the prior art may be modified in the manner suggested by the Examiner does not make the modification obvious unless the prior art suggested the desirability of the modification." *In re Fritch*, 972 F.2d 1260, 1266, 23 U.S.P.Q.2d 1780 (Fed Cir. 1992).

It is stated in the Office Action that:

Major discloses the claimed invention except for the arrangement of the tunnel junction layers with respect to the active layer. Kneissl discloses a light-emitting device as shown in Fig. 2 with an active layer 212, p type tunnel junction layer 216 and n type tunnel junction layer 218 with a tunnel junction in between. For the advantageous benefit of the light-emitting device, it would have been obvious to one of ordinary skill in the art at the time the invention was made to provide the p type tunnel junction layer between the active layer and the n type tunnel junction layer as taught by Kneissl or the other arrangement depending on the structure of the light emitting apparatus.

As stated above, *Major* fails to disclose, teach or suggest a tunnel junction. *Kneissl* discloses that a p-n tunnel junction between a p-type semiconductor layer and a n-type

semiconductor layer provides current injection for an edge-emitting nitride-based semiconductor laser structure. *See Kneissl*, Abstract. *Kneissl* discloses only a tunnel junction structure in which a p-type tunnel junction layer is located between an n-type tunnel junction layer and an active region.

However, Applicants respectfully submit that the proposed combination fails to teach each element of claims 2-3. As stated above, *Major* does not disclose a tunnel junction. Accordingly, the proposed combination fails to disclose, teach or suggest Applicants' "tunnel junction structure located to inject charge into the active region and including an n-type tunnel junction layer of a first semiconductor material, a p-type tunnel junction layer of a second semiconductor material and a tunnel junction between the tunnel junction layers, the first semiconductor material including gallium (Ga), nitrogen (N), arsenic (As) and a Group VI dopant," as recited in claim 1.

With particular regard to the claims, Applicants respectfully submit that the proposed combination fails to disclose, teach or suggest a light emitting device having a tunnel junction structure in which "the n-type tunnel junction layer is located between the p-type tunnel junction layer and the active region," as recited in claim 2.

#### **No Motivation to Combine *Major* and *Kneissl***

Applicants respectfully submit that there is no motivation to combine *Major* with *Kneissl* to arrive at the present invention. "Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the combination. Under section 103, teachings of references can be combined *only* if there is some suggestion or incentive to do so." *ACS Hospital Systems, Inc., v. Montefiore Hospital*, 732 F.2d 1572, 1577; 221 U.S.P.Q. 929, 933 (Fed. Cir. 1984). Further, "[t]here must be some reason, suggestion, or motivation found in the prior art whereby a person of ordinary skill in the field of the invention would make the combination." *In re, Oetiker*, 977 F.2d 1443, 1447, 24 U.S.P.Q.2d 1443 (Fed. Cir. 1992).

Applicants respectfully submit that there is nothing in *Major* or *Kneissl* that would motivate one having ordinary skill in the art to combine these references to arrive at the tunnel junction structure of the invention, which provides at least "a tunnel junction structure located to inject charge into the active region and including an n-type tunnel junction layer of a first semiconductor material, a p-type tunnel junction layer of a second semiconductor material and a tunnel junction between the tunnel junction layers, the first semiconductor

material including gallium (Ga), nitrogen (N), arsenic (As) and a Group VI dopant.”

Further, neither *Major* nor *Kneissl* provide either a reasonable expectation of success of combining the references to provide the tunnel junction structure, or show any relevance to the problem solved by Applicants’ invention. Specifically, Applicants respectfully submit that the Office Action fails to establish a *prima facie* case of obviousness because the Office Action has not pointed out the specific teachings in either *Major* or *Kneissl* that would motivate one having ordinary skill in the art to combine the references to arrive at Applicants’ invention. As stated above, *Major* does not disclose, teach or suggest a tunnel junction. Nowhere does *Major* even mention the use of a tunnel junction structure.

Accordingly, Applicants respectfully submit that dependent claims 2-3 are allowable in that they include features that are neither disclosed, taught nor suggested by the proposed combination. Furthermore, Applicants respectfully submit that dependent claims 2-3 are allowable for at least the reason that they depend from allowable independent claim 1. *In re Fine, supra*.

#### Claim 11

Claim 11 stands rejected under 35 U.S.C. § 103(a) as allegedly being unpatentable over *Major* in view of U.S. Patent No. 6,813,293 to Johnson *et al.* (hereafter *Johnson*).

It is stated in the Office Action that:

Major discloses the claimed invention except for the second material comprising at least one of indium, antimony, and bismuth. Johnson discloses a light emitting device as shown in Fig. 1 with a tunnel junction 14 with material including InAlGaAs and In. For the improvement of the tunnel junction structure or light emitting device, it would have been obvious to one having ordinary skill in the art at the time the invention was made to provide indium as taught by Johnson to Major because the material having indium has been well known in the art for tunnel junction layer.

As stated above, *Major* fails to disclose, teach or suggest a tunnel junction. *Johnson* discloses a vertical cavity surface emitting laser (VCSEL) having a tunnel junction. See *Johnson*, Abstract.

However, Applicants respectfully submit that the proposed combination fails to teach each element of claim 11. As stated above, *Major* does not disclose a tunnel junction. Accordingly, the proposed combination fails to disclose, teach or suggest Applicants’ “tunnel

junction structure located to inject charge into the active region and including an n-type tunnel junction layer of a first semiconductor material, a p-type tunnel junction layer of a second semiconductor material and a tunnel junction between the tunnel junction layers, the first semiconductor material including gallium (Ga), nitrogen (N), arsenic (As) and a Group VI dopant,” as recited in claim 1.

With particular regard to the claims, Applicants respectfully submit that the proposed combination fails to disclose, teach or suggest a light-emitting device having a tunnel junction structure in which “in which the second semiconductor material comprises at least one of indium, antimony and bismuth,” as recited in claim 11.

**No Motivation to Combine Major and Johnson**

Applicants respectfully submit that there is no motivation to combine *Major* with *Johnson* to arrive at the present invention. “Obviousness cannot be established by combining the teachings of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the combination. Under section 103, teachings of references can be combined *only* if there is some suggestion or incentive to do so.” *ACS Hospital Systems, Inc., v. Montefiore Hospital*, 732 F.2d 1572, 1577; 221 U.S.P.Q. 929, 933 (Fed. Cir. 1984). Further, “[t]here must be some reason, suggestion, or motivation found in the prior art whereby a person of ordinary skill in the field of the invention would make the combination.” *In re, Oetiker*, 977 F.2d 1443, 1447, 24 U.S.P.Q.2d 1443 (Fed. Cir. 1992).

Applicants respectfully submit that there is nothing in *Major* or *Johnson* that would motivate one having ordinary skill in the art to combine these references to arrive at the tunnel junction structure of the invention, which provides at least “a tunnel junction structure located to inject charge into the active region and including an n-type tunnel junction layer of a first semiconductor material, a p-type tunnel junction layer of a second semiconductor material and a tunnel junction between the tunnel junction layers, the first semiconductor material including gallium (Ga), nitrogen (N), arsenic (As) and a Group VI dopant.”

Further, neither *Major* nor *Johnson* provide either a reasonable expectation of success of combining the references to provide the tunnel junction structure, or show any relevance to the problem solved by Applicants’ invention. Specifically, Applicants respectfully submit that the Office Action fails to establish a *prima facie* case of obviousness because the Office Action has not pointed out the specific teachings in either *Major* or *Johnson* that would motivate one having ordinary skill in the art to combine the references to arrive at Applicants’



invention. As stated above, *Major* does not disclose, teach or suggest a tunnel junction. Nowhere does *Major* even mention the use of a tunnel junction structure.

Accordingly, Applicants respectfully submit that dependent claim 11 is allowable in that it includes features that are neither disclosed, taught nor suggested by the proposed combination. Furthermore, Applicants respectfully submit that dependent claim 21 is allowable for at least the reason that it depends from allowable independent claim 1. *In re Fine, supra*.

#### **Allowable Subject Matter**

Claims 6-9 and 22-23 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Applicants wish to thank Examiner for the indicated allowability of claims 6-9 and 22-23. However, Applicants have not yet amended independent claims 1 or 18 pending consideration of the foregoing remarks.

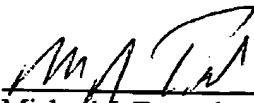
#### **CONCLUSION**

Should the Examiner have any comment regarding the Applicants' response or believe that a teleconference would expedite prosecution of the pending claims, Applicants request that the Examiner telephone Applicants' undersigned attorney.

Respectfully submitted,

**Smith Frohwein Tempel Greenlee Blaha LLC**  
**Customer No. 35856**

By:

  
Michael J. Tempel  
Registration No. 41,344  
(770) 709-0056